GRIZZLY BEAR DNA MARK–RECAPTURE SAMPLING IN THE WESTERN KITIKMEOT REGION OF NUNAVUT: 2022 and 2023 INTERIM PROGRESS REPORT

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Note: The SECR analysis of the 2022 and 2023 datasets is ongoing. Final report in early 2025 will provide estimates for the entire region (2021, 2022, and 2023 sampling areas) as well as yearly sampling areas.

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Introduction

Grizzly bears (*Ursus arctos*) are listed as a species of Special Concern in Canada under the Canadian *Species at Risk Act* (SARA) and are an important part of subsistence hunting by Inuit for economic, social and cultural purposes. Habitat fragmentation and loss due to development and anthropogenic mortality were considered the primary threats during the SARA listing process (COSEWIC 2012). While this is true for most parts of the species' Canadian range, the range fragmentation and habitat loss issues that affect southern or western grizzly bear populations may have limited application to barren-ground grizzly bear in Nunavut. Barren-ground grizzly bears occupying central Arctic tundra roam over larger areas and experience relatively little contact with humans (McLoughlin et al. 2003a, 2003c; Jessen 2017) and directional climate change has been improving habitat for bears in Nunavut (McLoughlin and Stenhouse 2021). Local knowledge, harvest records and research indicate an increase in numbers and range expansion eastward and northward (Clark 2007, Dumond et al. 2015, Jessen 2017, Awan et al. 2019, Barrueto et al. 2023). However, there are limited baseline data on grizzly bear distribution and density within Nunavut, in part because of the cost and challenge of surveying bears at low densities in remote areas.

The grizzly bear population in the western Kitikmeot Region around Kugluktuk was sampled intensively in 2008–2009 using a nearly uniform grid of posts for DNA hair sampling, resulting in an estimate of ~5.0 bears/1,000 km^2 (95% CI = 3.5–9.1 bears/1,000 km^2; Dumond et al. 2015). Re-analysis and modeling of the Dumond et al. (2015) data resulted in a revised but similar estimate of 5.6 bears/1,000 km^2 (95% CI = 4.5–7.0 bears/1,000 km^2; Appendix 1). To examine grizzly bear population trend since 2008–2009 and to provide a more precise estimate of bear abundance within the western Kitikmeot Region, in collaboration with the Kugluktuk Angoniatit Association we sampled hair in 2021 using clusters of sampling stations and a different design for hair snagging. This project provided precise population estimates for the area near Kugluktuk as detailed in a Government of Nunavut report (Awan et al. 2023).

In 2022 and 2023, regions to the east of the 2021 study area were sampled to allow an overall estimate of grizzly bear abundance for most of the mainland Kitikmeot region. These results are outlined in this report. We note that the main analysis is still in progress and therefore we provide only summaries. Estimates for the 2022 and 2023 surveys as well as combined estimates for the entire region will appear in future reports.

Methods

Hair snagging method

We adapted the hair-snagging tripod design from earlier studies conducted on the Arctic tundra (Izok Lake – K. Poole, Aurora Wildlife Research, unpublished data and Boulanger 2013; Hope Bay – Rescan 2012), and updated methods of Awan et al. (2019). We produced a video to illustrate the methodology (https://www.youtube.com/watch?v=uZ5FEFVrMas). Each tripod comprised of 6′ 2″ x 4″ pieces of rough lumber 5′ 3″ (160 cm) in length and secured at the corners with 3/16th (0.47 cm) aircraft cable. We wrapped the 3 upright 2″ x 4″ legs with double-stranded 15 gauge high-tensile barbed wire (5″ (13 cm) barb-spacing) to trap hairs from grizzly bears interacting with the tripod. In March 2021, tripod materials were prepared in Kugluktuk prior to deployment (barbed wire wrapping, cutting aircraft cable and felt, etc.) and shuttled by snowmobile to the sampling grids by Kugluktuk hunters. We assembled the tripods in the grid cells using a Bell 206B-LR helicopter for transportation (Figure 1).

Figure 1. Tripod deployment and check on the sub-grids, western Kitikmeot Region, 2021.

We placed non–reward commercial trapping lures (Long Distance Call and Beaver Castor; O'Gorman Lures, Montana, USA) on a piece of felt attached to the top of the tripod and poured ~200 ml commercial fish oil (Forsyth Lures, Alix, AB) on top to attract the bears. We recorded the GPS position of each tripod. During the sampling, we collected all visible hairs with forceps from the tripod and from the surrounding ground. We cleaned the barbed wire using a propane torch to burn any remaining hair and moved the tripod about 10 m to avoid cross-contamination between sampling sessions. We installed a fresh set of lures after every check. We air-dried collected hairs in labelled (station number, tripod leg and date) individual paper envelopes and stored them at room temperature. We recorded the number of caribou (*Rangifer tarandus)*, muskoxen (*Ovibos moschatus*), and other species sighted or wildlife signs observed during the tripod set-up and checks and while flying between tripods.

Estimation of density and abundance

We used spatially explicit capture–recapture (SECR) analysis, an extension of conventional capture–recapture methods, specifically to estimate the density of spatially distributed populations (Efford 2004, Borchers and Efford 2008, Royle et al. 2014). SECR avoids most of the concerns about geographic closure that featured in earlier analyses using conventional closed-population methods.

The data used for SECR are spatial detection histories; each history is a record of the particular sites (stations) at which each individual was detected. The detected individuals are a sample of those centred in the surrounding area – the chance of being detected declines with distance from the activity centre. By fitting a curve for the decline in detection probability with distance from the activity centre, we were able to estimate both (i) the parameters of the curve, and (ii) the density of activity centres (including animals that were not detected; Figure 2).

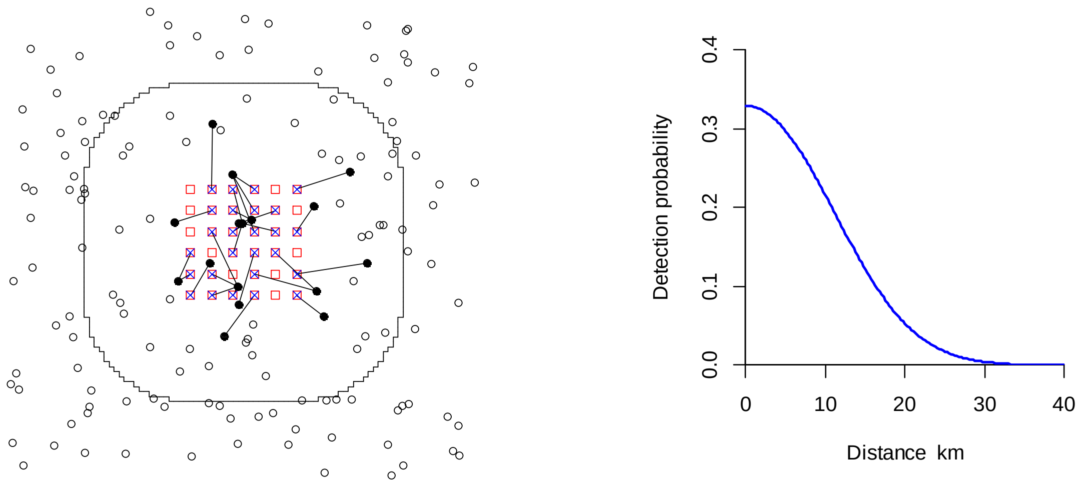

Figure 2. Spatially explicit capture–recapture conceptual model. Animal activity centres (dots) are distributed across the wider landscape. Animals centred near a station (red squares) have a high probability of detection (blue crosses; see also hypothetical distance-detection function on right). The activity centres of animals detected at least once are shown as filled dots (a single sampling interval is shown). Animals centred beyond an arbitrary outer perimeter (solid line) have such low probability of detection that they can be ignored in model fitting.

For SECR, the population is thought of as a distribution of animal activity centres in 2 dimensions (open circles in Figure 2). We can ignore centres that are very far from detectors because these animals stand negligible chance of detection, and this has computational benefits. The criterion for ignoring distant animals is usually a buffer of a certain width around the detectors (represented by the perimeter line in Figure 2). The area within this boundary becomes the area of integration for maximum likelihood or the 'state space' of centres in Bayesian models (e.g., Royle et al. 2014; the term 'habitat mask' is used in R package 'secr').

Where habitat extends indefinitely in all directions, as appears to be the case for grizzly bears, the placement of the boundary is arbitrary. The area should merely be large enough that enlarging it further has no effect on density estimates because only un-detectable animals are added. This is achieved by using a buffer around the stations that is large compared to the radius of home ranges during the sampling period. Annual home ranges of male grizzly bears in the central Arctic averaged approximately 7,250 km^2 (~48 km radius circle; McLoughlin et al. 2003a). Whether the buffer is large enough can be tested once pilot values are available for σ, the spatial scale (width parameter) of the blue detection curve in Figure 2. The habitat mask included all land within a 60-km radius of any tripod. The mask was discretized as 4-km pixels. We modelled detection hazard as a negative exponential function of distance between a bear's activity centre and a tripod (detectfn 'HEX' in secr). Detection parameters were modelled as sex-dependent.

We fitted SECR models by maximum likelihood using the R package 'secr' 4.5.6 (Efford 2022a).

Sampling designs for 2022 and 2023

Design of the 2022 and 2023 field sampling (Figure 3) was based upon results of the 2021 field effort with two regional areas sampled to the east in 2022 and 2023 (Awan et al 2023). A spatial algorithm was used to ensure each subgrid sampled equal areas within each region (Walvoort et al. 2010).

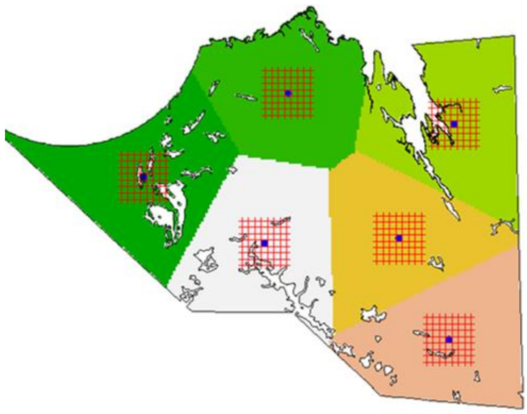

Figure 3: Placement of subgrids within each region.

The general objective of 2022 and 2023 was to obtain estimates of larger regions with similar or reduced effort than the 2021 survey. To do this we applied an “independent” subgrid approach with each subgrid being large enough to obtain a representative sample of detections and redetections of male and female grizzly bears. This approach contrasted with the 2021 survey which relied on redetections of individual bears across multiple subgrids. As detailed in Awan et al (2023) a simulation study was used to determine optimal subgrid size to sample the central and eastern regions of the study area under the general constraint of approximately 190 tripods employed for 3 sampling sessions. Subgrid sizes ranged from a grid of 5x5 to 10x10 tripods with spacings ranging from 4 to 10 km. Spatially explicit detection parameters from the 2021 study were used for simulations. Simulation results suggested that subgrid sizes of 8x8 to 10x10 tripods with spacing of 4 to 6 km would result in the most precise estimates (Figure 4).

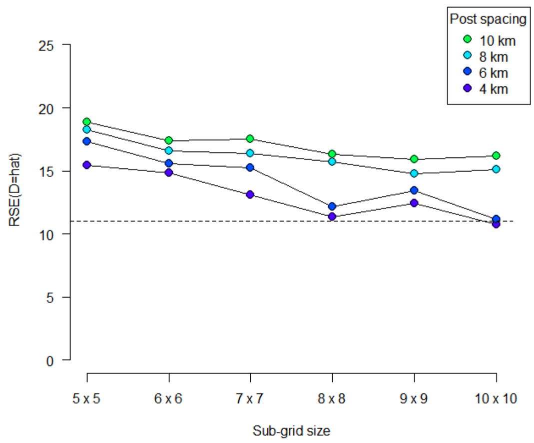

Figure 4: Simulation results to determine optimal tripod spacing and subgrid size.

The resulting subgrid design for 2022 and 2023 employed 6 8x8 subgrids with 6 km tripod spacing. Three of the subgrids were sampled in 2022 (central region) and 3 subgrids were sampled in 2023 (eastern region; Figure 5).

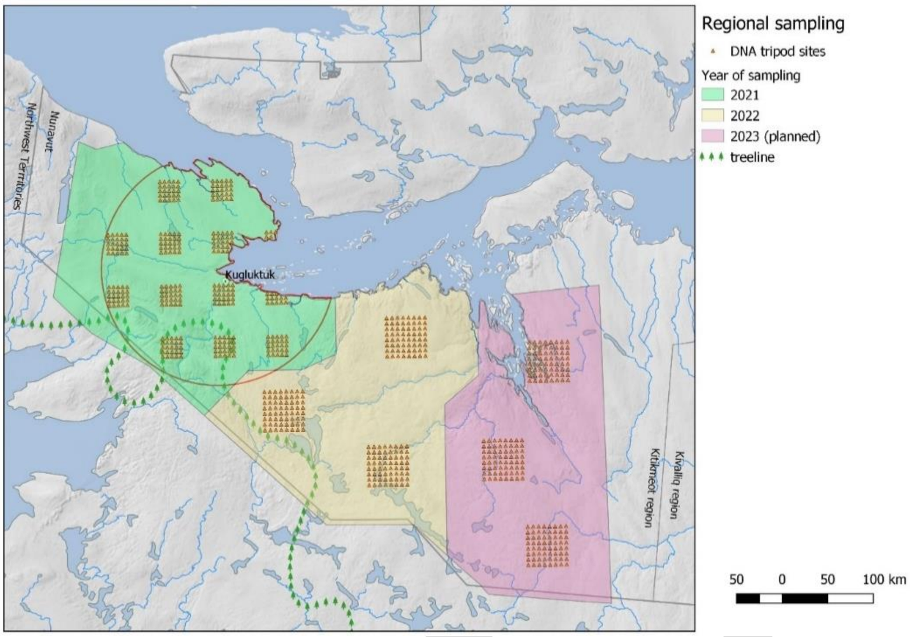

Figure 5. Division of western portion of mainland Kitikmeot Region into sectors sampled for grizzly bears in 2021 (western; 54,200 km²) and 2022 (central; 51,500 km²), and 2023 (eastern; 50,800 km²). Red circle denotes the 2021 core study area, and red crosses mark the used or proposed locations of hair snag stations (tripods).

There were similarities and differences in each yearly design employed (Table 1). One noteworthy difference was that the cumulative number of stations sampled decreased substantially with each year sampled through to 2022, demonstrating the potential increase in sampling efficiency from the uniform grid (2008-2009) to the dependent subgrid (2021) to independent subgrids (2022 and 2023).

Table 1. Comparison of the 2008–2009, 2021, 2022, and 2023 western Kitikmeot Region grizzly bear sampling designs.

Attribute	**2008–2009**	**2021**	**2022**	**2023**
Stations	393	291	187	192
Spacing	10 km	5 km	6 km	6 km
Coverage	Uniform	Clustered	Clustered	Clustered
Layout	1 post per grid square	13 sub-grids (5 x 5)	3 subgrids (8 x 8)	3 subgrids (8 x 8)
Sampling sessions	2 x 2 years	3 x 1 year	3 x 1 year	3 x 1 year
Cumulative detectors sampled	786 (x 2 years) =1,572	873	561	576
Sampling interval	~14 days	~14 days	~14 days	~14 days
Sample retrieval	Jul–Aug	22 Jul – 27 Aug	21 Jul – 31 Aug	21 Jul – 27 Aug
Detector design	Post	Tripod	Tripod	Tripod
Lure	Commercial long distance call and beaver castor	Commercial fish oil, long distance call and beaver castor	Commercial fish oil, long distance call and beaver castor	Commercial fish oil, long distance call and beaver castor

Results

Here we provide summary results as the SECR analysis is in progress for the 2022 and 2023 sample years.

Detections and redetections

Table 2 provides summary statistics for 2022 and 2023. Overall, 55 (30F and 25M) and 60 (38F and 22M) were detected in sampling efforts in 2022 and 2023, respectively. The number of new bears detected each sampling session decreased by session for males and females for both 2022 and 2023, suggesting that sampling was effective in targeting bears within the survey areas. In addition, detection frequencies (the number of sessions an individual bear was detected) demonstrated that many bears were detected in more than 1 sampling session suggesting that the designs were effective in redetecting bears.

In the context of study design efficiency, the number of bears detected should be roughly equal to the number of redetections (Efford and Boulanger 2019). In this context, there were 55 bears detected in 2022 with 45 redetections. In 2023 there were 60 bears detected and 46 redetections. This suggests that the designs were relatively efficient as indicated by relatively similar numbers of bears detected and redetected.

Table 2: Summary statistics for 2022 and 2023

	Sex/session											
	Males and Females				Females				Males			
Year/statistic	1	2	3	Total	1	2	3	Total	1	2	3	Total
2022												
Bears detected	20	30	40	90	15	18	21	54	5	12	19	36
New bears detected	20	17	18	55	15	9	6	30	5	8	12	25
Detection frequency[a]	30	15	10	55	14	8	8	30	16	7	2	25
Tripods visited	29	43	49	121	21	31	28	80	8	15	23	46
Tripods employed	187	187	187	561	187	187	187	561	187	187	187	561
2023												
Bears detected	36	32	38	106	24	24	27	75	12	8	11	31
New bears detected	36	11	13	60	24	8	6	38	12	3	7	22
Detection frequency	27	20	13	60	13	13	12	38	14	7	1	22
Tripods visited	46	40	60	146	35	32	47	114	17	11	17	45
Tripods employed	192	192	192	576	192	192	192	576	192	192	192	576

[a] Detection frequency refers to the number of sessions (columns 1, 2, and 3) individual bears were detected.

Summary of spatial detections

A map of individuals detected per subgrid reveals variation, especially in 2021 where subgrid h detected 60 individuals which was notably higher than other subgrids (Figure 6). In contrast, the number of bears detected in each subgrid in 2022 and 2023 was relatively even except for subgrid 2 in 2022, where only 9 bears were detected.

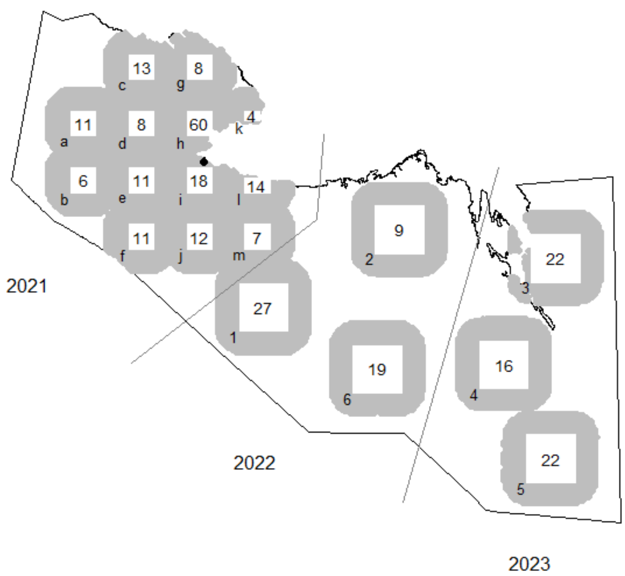

Figure 6: Individuals detected per grid (small 25 posts, large 64 posts).

The number of bears detected per post per session provides an index of density since it accounts for different numbers of tripods in each subgrid (Figure 7). Indices suggest relatively similar distributions in most of the subgrids sampled in 2022 and 2023 except for subgrid 2 sampled in 2022 that had lower detections per post. Most subgrids in 2021 also had similar indices with the exception of subgrids h and l which had higher numbers of detections per post. The distribution of detections in 2021 is discussed further in Awan et al (2023).

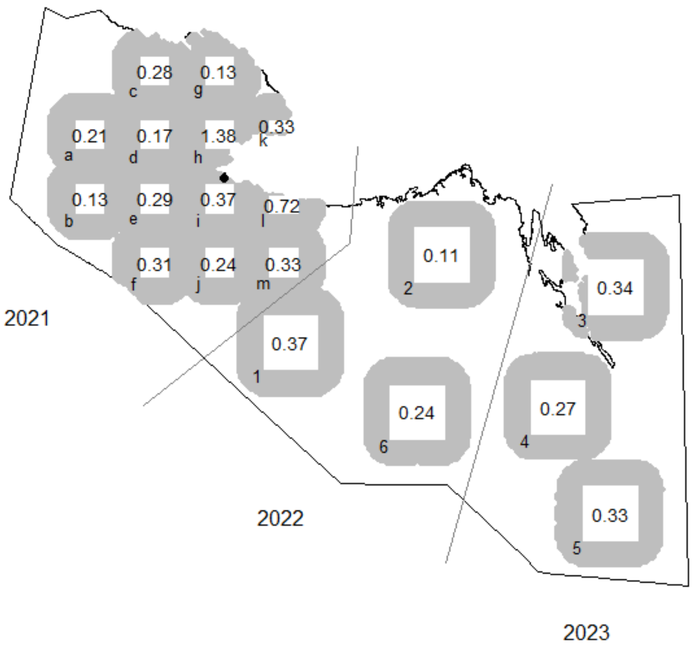

Figure 7: The number of bears detected per post per session for each yearly subgrid.

Movements of bears during sampling

There were few observed movements of individual bears among subgrids in 2022 and 2023 in comparison to 2021 where subgrids were closer in proximity (Figure 8: roughly 35 km apart in 2021 compared to 70 km apart in 2022 and 2023). The lack of movement among subgrids in 2022 and 2023 was anticipated; individual subgrids were designed to be large enough to provide spatial re-detections of individual bears for SECR analysis.

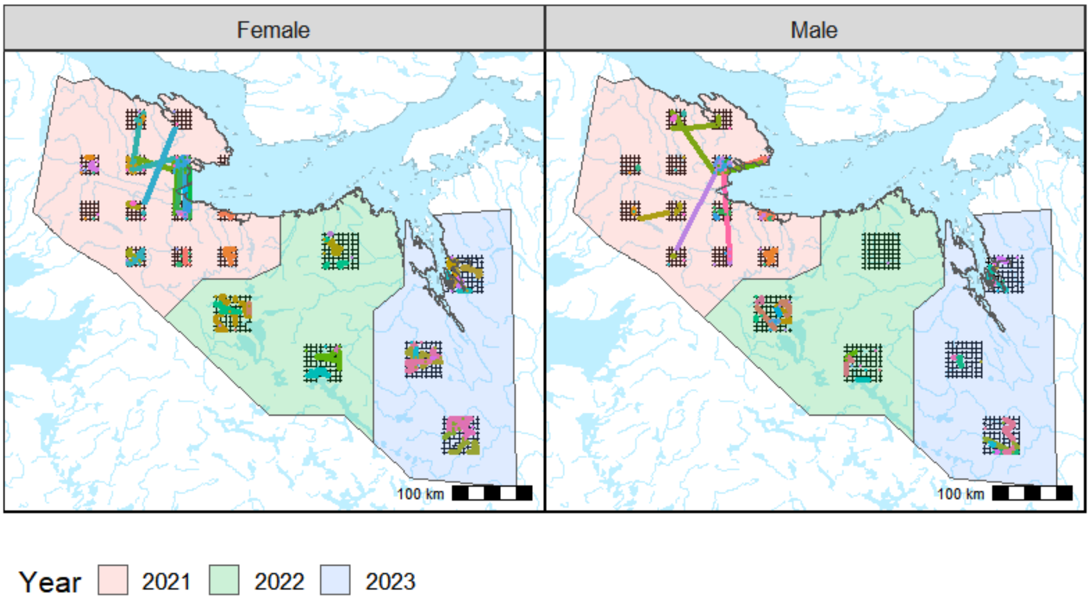

Figure 8: Movements of bears within each sampling year for 2021, 2022, and 2023

Larger-scale movements occurred between years only for male bears with 3 males being detected in 2021 and 2022/2023 and 1 male being detected in 2022 and 2023 (Figure 9).

- Male 2-13A2-X5 was detected on Grid 13 ('m') (post 13A2) on 2021-08-12 and 42 km away on Grid 1 (post 1H1) on 2022-08-31.
- Male 2-9B1-X2 was detected on Grid 9 ('i') (posts 9B1 2021-08-13, 9A2 2021-08-27) and the following year on new Grid 1 (1F5 2022-08-31, 1D6 2022-09-01). The between-year movement was 131 km.
- Male 1-9C2-TOP was detected on Grid 9 ('i') (posts 9C2,9C5) on 2021-07-30 and 2 years later on new Grid 5 (5A3 2023-07-21, 5A8 2023-08-05). The between-year movement was 448 km.
- Male 2-6D4-X1 was detected on Grid 6 (post 6D4) on 2022-08-08 and 196 km away on Grid 3 (post 3A3) on 2023-08-28. Curiously, this individual was also detected on 2023-08-05 at old (2022) post 6C3 (not part of present analysis). This implies a movement of 204 km in August 2023.

We suspect these movements were subadult males that often will have larger movement patterns potentially tied to dispersal from natal areas. These movements likely occurred outside of the time-scale of sampling (July-August) and have minimal effect on density estimates.

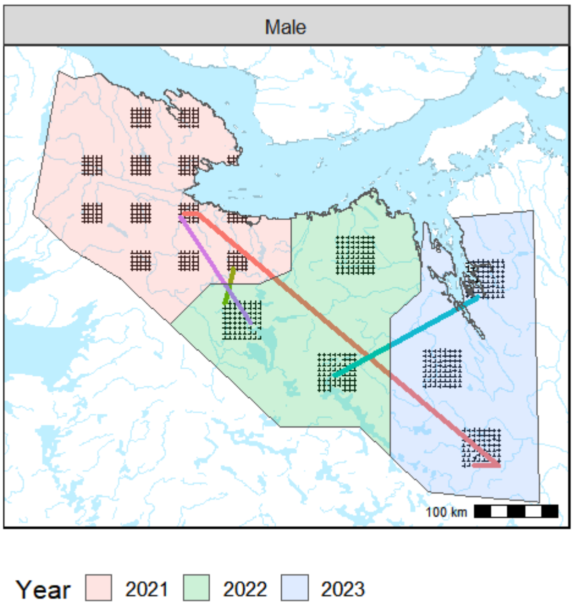

Figure 9: Movements of male bears across all years for bears detected in more than one year of sampling

Summary of ongoing analyses

The SECR analysis of the 2022 and 2023 datasets is ongoing. Preliminary results indicate that precise estimates of density and abundance were obtained for the 2022 and 2023 datasets. Future reports will provide estimates for the entire region (2021, 2022, and 2023 sampling areas) as well as yearly sampling areas.

Acknowledgements

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Literature cited

Awan, M., M. Efford, and J. Boulanger. 2023. Grizzly Bear DNA Mark–Recapture Sampling in the Western Kitikmeot Region of Nunavut, 2021. Department of Environment, Government of Nunavut.

Awan, M., M. Efford, and J. Boulanger. 2019. Estimates of grizzly bear density from mark-recapture DNA sampling, Kivalliq Region, Nunavut, 2016-2017. Draft interim report, Department of Environment, Wildlife Research Section, Igloolik, NU. September 2019.

Barrueto, M., T. D. Jessen, R. Diepstraten, and M. Musiani. 2023. Density and genetic diversity of grizzly bears at the northern edge of their distribution. Ecosphere doi.org/10.1002/ecs2.4523

Borchers, D. L. and M. G. Efford. 2008. Spatially explicit maximum likelihood methods for capture–recapture studies. Biometrics 64: 377–385.

Clark, D. A. 2007. Local and regional-scale societal dynamics in grizzly bear conservation. Dissertation, Wilfrid Laurier University, Waterloo, Ontario, Canada.

Committee on the Status of Endangered Wildlife in Canada [COSEWIC]. 2012. COSEWIC assessment and status report on the grizzly bear *Ursus arctos* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, Ontario, Canada.

Dumond, M., J. Boulanger, and D. Paetkau. 2015. The estimation of grizzly bear density through hair-snagging techniques above the tree line. Wildlife Society Bulletin 39: 380–402.

Efford, M. 2004. Density estimation in live-trapping studies. Oikos 106:598–610.

Efford, M. G. 2023. Robust sampling design for spatially explicit capture-recapture. Presentation at Euring 2023 CNRS Montpellier 17 April 2023.

Efford, M. G., and J. Boulanger. 2019. Fast evaluation of study designs for spatially explicit capture–recapture. Methods in Ecology and Evolution 10:1529–1535.

Efford, M. G., and M. R. Schofield. 2020. A spatial open-population capture–recapture model. Biometrics 76:392–402. DOI: 10.1111/biom.13150

Efford, M. G., and M. R. Schofield. 2022. A review of movement models in open population capture–recapture. Methods in Ecology and Evolution 13:2106–2118. https://doi.org/10.1111/2041-210X.13947

Efford, M. G., B.Warburton, , M. C. Coleman, and R. J. Barker. 2005. A field test of two methods for density estimation. Wildlife Society Bulletin 33: 731–738.

Efford, M., and J. Boulanger. 2019. Fast evaluation of study designs for spatially explicit capture recapture. Methods in Ecology and Evolution 10:1529-1535.

Jessen, T.R. 2017. Spatiotemporal factors influencing the distribution and abundance of grizzly bears (*Ursus arctos*) inhabiting the barren grounds of the central Canadian Arctic. Master's Thesis, University of Calgary, Alberta, Canada.

McLoughlin, P. D., H. D. Cluff, R. J. Gau, R. Mulders, R. L. Case, and F. Messier. 2003a. Effect of spatial differences in habitat on home ranges of grizzly bears. Ecoscience 10:11–16.

McLoughlin, P. D., M. K. Taylor, H. D. Cluff, R. J. Gau, R. Mulders, R. L. Case, and F. Messier. 2003c. Population viability of barren-ground grizzly bears in Nunavut and the Northwest Territories. Arctic 56:185–190.

McLoughlin, P. D., and G. B. Stenhouse. 2021. Mapping ecological data and status of grizzly bears (*Ursus arctos*) in Canada. Technical report to NatureServe Canada. 71 pp.

Royle, J. A., R. B. Chandler, R. Sollmann, and B. Gardner. 2014. Spatial capture–recapture. Waltham, USA: Academic Press.

Walvoort, D. J. J., D. J. Brus, and J. J. de Gruijter. 2010. An R package for spatial coverage sampling and random sampling from compact geographical strata by k-means. Computers & Geosciences 36:1261-1267.